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Sitka Spruce and Western Hemlock Beach Logs in Southeast Alaska:

Suitability for Lumber, Pulp, and Energy

Susan Ernst, Marlin E. Plank, and Donald J. Fahey

Authors

SUSAN ERNST and MARLIN E. PLANK are research forest products technologists, Forestry Sciences Laboratory, P.O. Box 3890, Portland, Oregon 97208. DONALD J. FAHEY, retired, was a research forest products technologist, Forest Products Laboratory, Madison, Wisconsin.

Abstract

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The suitability of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) beach logs in southeast Alaska for lumber, pulp, and energy was determined. Logs were sawn at a cant mill in southeast Alaska and at a dimension mill in northern Washington. Volume and value recovery was compared among samples of live, recent dead, and older dead classes of logs. The live and recent dead samples produced about the same quantity and quality of lumber. The older dead sample produced less volume and lower quality lumber. There were no difficulties in pulping or gasification of the beach logs, but a higher salt content may cause problems with boiler corrosion and stack emissions.

Keywords: Wood utilization, beach logs, western hemlock, Sitka spruce, southeast Alaska.

Summary

The lack of information about the product potential of beach logs in southeast Alaska is a major obstacle to their efficient utilization. This paper provides information about the suitability of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) beach logs for lumber, pulp, and energy. A lumber recovery study was conducted in 1982 by the Timber Quality Research unit (Forestry Sciences Laboratory, Portland, Oregon) in cooperation with Region 10 of the USDA Forest Service and with the State of Alaska. Samples of chips were provided to the Forest Products Laboratory for analysis of pulping characteristics, and to the University of California at Davis for gasification analysis. The University of Washington obtained samples for salt content and calorimeter analysis from the same beaches that were sampled in the lumber recovery study. Although the energy analyses have already been published (Lamorey and Goss 1983, Smith and Woodfin 1984), they are summarized here to show the entire range of uses for beach logs.

Logs were sawn at a cant mill in southeast Alaska and a dimension mill in northern Washington. Volume and value recovery was compared among live, recent dead, and older dead samples. Volume recovery was about the same for the live and the recent dead samples. Less volume was recovered from the older dead logs because they were more defective.

Average lumber value was the same for all samples for each species at the cant mill. At the dimension mill, the average value was the same for only the live and recent dead samples. The average lumber value of the older dead was lower because of heart decay and checks.

Throughout the sawing at the cant mill, samples were taken of the chips produced from the slabs, edgings, and trim ends. These samples were then analyzed to test their suitability for sulfite and kraft pulp. The results showed that the chips from spruce beach logs had pulping characteristics similar to the live material. This was also true for the kraft pulping of hemlock; however, the sulfite pulping did require a longer cooking schedule for the beach log sample than for the live sample.

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Terminology and Abbreviations

Cubic recovery percent (CR%) the cubic feet of lumber produced from a cubic foot of log input. Log volume can be expressed as a percentage of the gross, net (firmwood), or product (merchantable) cubic scale. In this paper the CR% is based on product cubic scale.

Overrun (OR) the board feet of lumber produced which is greater than the net board feet of the log, expressed as a percentage of the net board feet of the log. Although overrun has traditionally (and in this paper) been expressed as a percentage of net Scribner scale, it can also be expressed as a percentage of gross Scribner scale.

Dollars per thousand board feet of lumber tally ($/MLT) the average value of the lumber produced, based on the lumber produced and the pricing structure used in this paper.

Dollars per hundred cubic feet of log scale ($/CCF) the total value of the lumber produced from a log divided by the cubic scale of the log. Cubic scale volume may be gross, net (firmwood), or product (merchantable). In this paper the $/CCF is based on product cubic scale.

kPa	kilopascal
mPa•s	millipascal second
kPa•m²/g	kilopascal square meter per gram
mN•m²/g	millinewton square meter per gram
N•m/g	newton meter per gram
kg/m³	kilogram per cubic meter
R^2	coefficient of determination
MSE	mean square error

Introduction

The beaches of southeast Alaska are covered with extensive amounts of wood residues (fig. 1). Logs and broken pieces, originating from log rafts, boom sticks, blown down timber, and docks, have accumulated over many years. They are a hazard to navigation and have also been described as unsightly, but they may be an additional source of wood fiber for solid wood products, pulp, and energy uses.

Figure 1.—Typical logs on beaches in southeast Alaska.

Several attempts have been made to estimate the magnitude of the beach log resource. Estimates of volume range from 2,600 cubic feet per mile (Davis 1976) to 16,000 cubic feet per mile (USDA Forest Service 1982). The techniques used varied from a general aerial survey of hundreds of miles of coastline[1] to a very detailed intensive ground survey of 33 miles of beach (Davis 1976). Estimates of the volume by species also vary because of both the difficulty in determining species and the different locations of the samples. What can be agreed on is that most of the material is on the beaches along the main transportation routes between the woods and the mills, and the majority of the volume is on the shores exposed to prevailing winds and currents. Very little material is found on the beaches exposed to the open ocean and the beaches north of Lynn Canal.

Along with the difficulty of developing a reliable inventory, several other problems have to be addressed if the beach log material is to be used: (1) the difficulty of logging the beaches and transporting the material to users; (2) the adverse reputation of beach logs because of salt content and imbedded rocks and iron; (3) the reluctance of buyers to purchase products cut from beach logs, and a preference for and the availability of green timber; (4) the lack of knowledge about the amount and quality of lumber and cants that can be produced from beach logs; and (5) the lack of information for alternative uses such as pulp and energy.

[1] Letters on file (99-03 Beach Log Recovery Study correspondence) Timber Quality Research unit, Forestry Sciences Laboratory, P.O. Box 3890, Portland, OR 97208.

A lumber recovery study was conducted in 1982 by the Timber Quality Research unit (Forestry Sciences Laboratory, Portland, Oregon) in cooperation with Region 10 of the USDA Forest Service and with the State of Alaska. This study provides information about recovery of volume and value for dimension lumber and cants sawn from beach logs. In addition, samples of chips were provided to the Forest Products Laboratory (Madison, Wisconsin) for analysis of pulping characteristics, and to the University of California at Davis for gasification analysis. The University of Washington obtained samples for salt content and calorimeter analysis from the same beaches that were sampled in the lumber recovery study. Although the energy analyses have already been published (Lamorey and Goss 1983, Smith and Woodfin 1984), they are summarized here to show the entire range of uses for beach logs.

Lumber

Our objectives for lumber were to estimate the volume and value recovery of the lumber and cants that can be produced from western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) beach logs; to compare recovery among two classes of beach logs and a live control sample; and to contrast recovery between two sawmills, a cant mill and a dimension mill.

Methods

Sample.—Although logs are scattered on the beaches from Dixon Entrance to Lynn Canal along the main transportation routes in southeast Alaska, our sample areas were limited to the beaches adjacent to the Wrangell-Petersburg area. This area was chosen after an aerial survey of a variety of beach types (sandy vs. rocky) and geographic locations (north vs. south) showed little difference in the size and species of wood on the beaches. The logs were selected from five locations (fig. 2). The sample was stratified by species, diameter, and deterioration class (table 1). Only western hemlock and Sitka spruce logs were sampled. The diameters ranged from 7 to 27+ inches; minimum log length was 20 feet. The logs were separated into recent and older dead classes. These classes are subjective but the recent dead were brown, appeared to be fresher logs, and were closer to the water; whereas the older dead were gray, were higher on the beach, had little or no sapwood left, or contained sap rot (fig. 3). A control sample of logs from live trees for each species was also chosen to match the diameter distribution of the beach log sample. The control sample of hemlock logs for the cant mill was selected from logs in that mill yard. Because the cant mill had no live spruce logs and only a limited supply of hemlock logs, the remainder of the control samples were selected from log decks in a mill yard in Wrangell, Alaska.

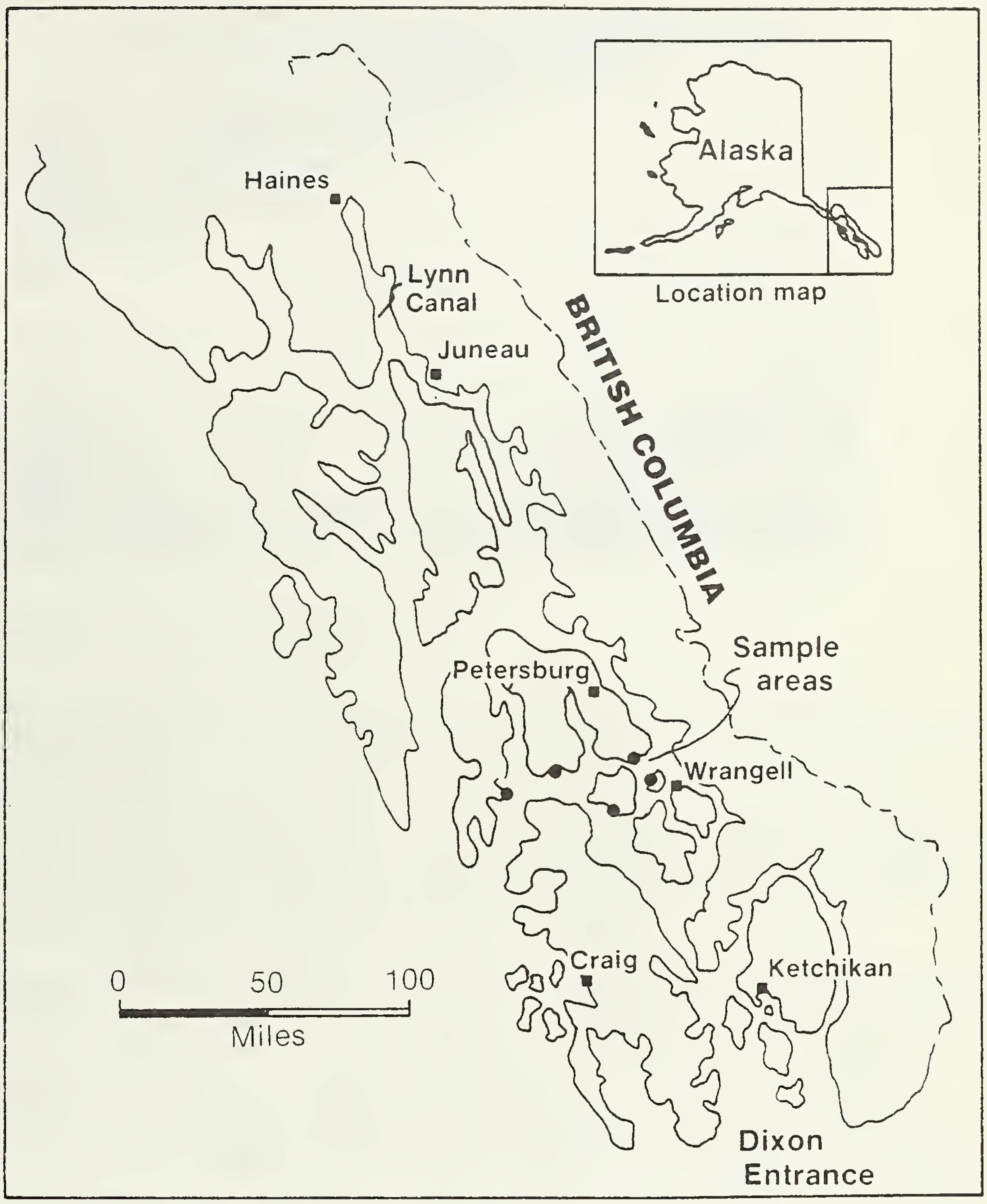

Figure 2.—Approximate locations of the sample areas.

Table 1—Number of sample logs by diameter and species for each deterioration class of beach logs in southeast Alaska

Diameter	Sitka spruce			Western hemlock		
	Live	Recent dead	Older dead	Live	Recent dead	Older dead
Inches						
			CANT MILL			
11-12	4	6	4	4	7	5
13-14	5	2	3	6	12	5
15-16	6	2	1	5	11	5
17-18	6	9	2	6	7	7
19-20	3	2	3	4	9	2
21-22	4	2	3	4	4	2
23-24	5	4	3	6	5	5
25-26	2	2	4	3	3	3
27+	4	3	3	3	1	1
Total	39	32	26	41	59	35
			DIMENSION MILL			
7-8	3	1	--	--	7	2
9-10	5	1	1	11	6	5
11-12	6	2	1	3	13	10
13-14	3	5	3	5	18	5
15-16	7	1	6	6	20	8
17-18	3	2	4	6	7	3
19-20	3	1	4	4	8	6
21-22	9	1	5	3	8	2
23-24	3	1	7	6	6	3
25-26	5	4	1	5	5	7
27+	2	--	2	1	2	3
Total	49	19	34	49	100	54

Figure 3.—Older dead beach log with sap rot and weather checks.

Scaling.—After the beach logs were salvaged, all the logs were rolled out and scaled by both Scribner (USDA Forest Service 1973) and cubic rules (USDA Forest Service 1978). Each log was tagged to maintain its identity throughout scaling and processing. Shake, dry rot, and checks were the most common defects for all classes of logs. Shake occurred mainly in the live hemlock samples. The absence of shake from the beach log samples may be attributed to the fact that shake is highly correlated to the presence of wetwood (Ward and Pong 1980), and logs with wetwood tend to sink so they do not reach the beach.

Milling.—The major wood product in Alaska is cants for export. An alternative product is dimension lumber for domestic use. Therefore, two mills were used to process our sample of beach logs; a dimension mill, Seaboard Lumber Company in Seattle, Washington, and a cant mill, Mitkof Lumber Company in Petersburg, Alaska. The dimension mill had a single-cut, slant-band headrig, a horizontal resaw, a sash gang saw, an optimizing edger, a single arbor edger, a trim saw, and a single cut vertical resaw. The dimension mill sawed logs from 7 to 27+ inches in diameter into 1- and 2-inch lumber that was then kiln dried. The cant mill had a circular headrig, an edger, and a trimsaw; it sawed logs from 11 to 27+ inches in diameter into 4-, 6-, and 8-inch-thick cants.

All dimension lumber in both mills was graded by a West Coast Lumber Inspection Bureau grade inspector according to West Coast Lumber Inspection Bureau (1970) grading rules. The cant grades are export grade specifications which are contractually agreed on by the mill owners and the buyers from Japan (appendix 1). Four lumber grades for each species were used at the cant mill: F, S, O, and Light Framing for spruce; No. 1, No. 2, Regular B, and Light Framing for hemlock. All the dimension grades were grouped together into Light Framing because they are a small part of the normal production.

The lumber at the dimension mill was grouped into four grades: Clear, Standard and Better, Utility, and Economy. The Clear includes B, C, and D Clear, and the Standard and Better includes Select Structural, Construction, and Standard grades.

Analysis

Recovery of both the volume and the value of products was analyzed for each mill. The analysis includes the two mills, the two species, two deterioration class samples, and a control sample.

Volume.—Two dependent variables have been used for evaluating recovery of lumber volume: cubic recovery percent (CR%) and overrun (OR). Cubic recovery percent has the advantage of being more consistent because it is based on cubic volume measurements for both lumber and logs. Overrun relates the volume of lumber produced to the net Scribner scale which is used as the marketing unit for logs. Both of these variables were regressed against small-end diameter (D) and transformations of D to find the equation that best fit the data. The models tested were:

$$y = b_0 + b_1 x,$$
$$y = b_0 + b_1 x + b_2 1/x,$$
$$y = b_0 + b_1 x + b_2 1/x + b_3 1/x^2.$$

Coefficient of determination (R^2) and mean square error (MSE) were used as criteria of goodness of fit. Covariance analysis was used to test for differences in regression equations among the older dead, recent dead, and live log samples for each species; analysis of variance and Tukey's test (Draper and Smith 1981) were used to test for differences among means when the dependent variables were not related to diameter. A $P \leq 0.05$ level of significance was used in all statistical tests.

Value.—Two dependent variables were used to evaluate recovery of value: dollars per thousand board feet of lumber tally ($/MLT) and dollars per hundred cubic feet of log scale ($/CCF). Dollars per thousand lumber tally reflects only the value of the lumber produced, whereas $/CCF includes both scaled defect and recovery of volume along with lumber value. The same models and criteria of evaluation were used for analyzing both volume and value.

Volume by grade.—The $/MLT is directly related to the volume of lumber produced in each lumber grade. Because of this, the prediction equations for the volume in each of the lumber grades were developed for the species and deterioration class combinations determined in the analysis of $/MLT. The models tested and criteria of evaluation used are the same as those used for volume and value analysis.

Results and Discussion

Volume.—Neither CR% nor OR had a significant relationship with diameter for the cant mill. Analysis of variance and Tukey's test were used to compare the means among the samples of older dead, recent dead, and live logs. All possible combinations of samples were tested for CR%. The live and recent dead samples were not significantly different, but they were significantly different from the older dead sample. This was true for both hemlock and spruce (table 2). These differences exist in CR% because of market conditions that make it more profitable to chip off-color (grayish—the color of weathered logs) material from the older dead sample.

Table 2—Overrun and cubic recovery percent with 95-percent confidence intervals for the cant mill, by species and deterioration class for the beach logs from southeast Alaska

Species and deterioration class	Cubic recovery percent	95-percent confidence interval	Overrun	95-percent confidence interval
			Percent	
Sitka spruce:				
Live and recent dead	68	8	1/ 48	1/ 20
Older dead	57	7		
Western nemlock:				
Live	2/ 60	2/ 6	16	14
Recent dead			33	18
Older dead	41	9	-9	25

1/ All spruce combined.

2/ Live and recent dead combined.

Tests of the means for OR for the cant mill showed no difference among any of the classes of spruce, but significant differences among all the hemlock classes. The differences among hemlock are due to the amount of defect and the market conditions. The older dead sample of hemlock was more defective and off color than the recent dead and live samples. Because hemlock cants are worth considerably less than spruce cants, a correspondingly large amount of the poorer quality hemlock was chipped.

Table 3—Cubic recovery percent with 95-percent confidence interval for the dimension mill, by species and deterioration class for the beach logs from southeast Alaska

Species and deterioration class	Cubic recovery percent	95-percent confidence interval
Western hemlock:		
Live and recent dead	62	3
Older dead	53	3
Sitka spruce 1/	61	4

1/ All spruce logs are combined.

Cubic recovery percent for the dimension mill had no significant relationship with diameter for either the hemlock or the spruce logs. Comparison of the mean CR% (table 3) for each of the samples showed no significant difference for any of the spruce logs. The hemlock live and recent dead samples showed no difference, but they were significantly different from the older dead sample.

Overrun did have a significant relationship with diameter for both species for the dimension mill. Covariance analysis showed no difference between the hemlock samples (fig. 4). The spruce live and recent dead samples were not significantly different, but the combined live and recent dead samples were different from the older dead sample. The OR curve for the older dead spruce logs is higher than the curve for the combined live and recent dead logs because of excessive scale deductions for defect in the older dead sample.

Value.—The analysis of value for both the hemlock and the spruce samples at the cant mill showed significant relationships between $/MLT and diameter. Covariance analysis of the regression lines for the deterioration classes showed no statistical differences among them; therefore, all classes were combined into one regression line for each species. The regression lines for the spruce logs are higher than the line for the hemlock logs (fig. 5) because of the higher price for the F grade of spruce cants (appendix 2). The spruce regression line increases linearly with diameter because the proportion of the highest grade cants continues to increase, whereas the hemlock regression line levels off as production of the highest grade of hemlock cants levels off.

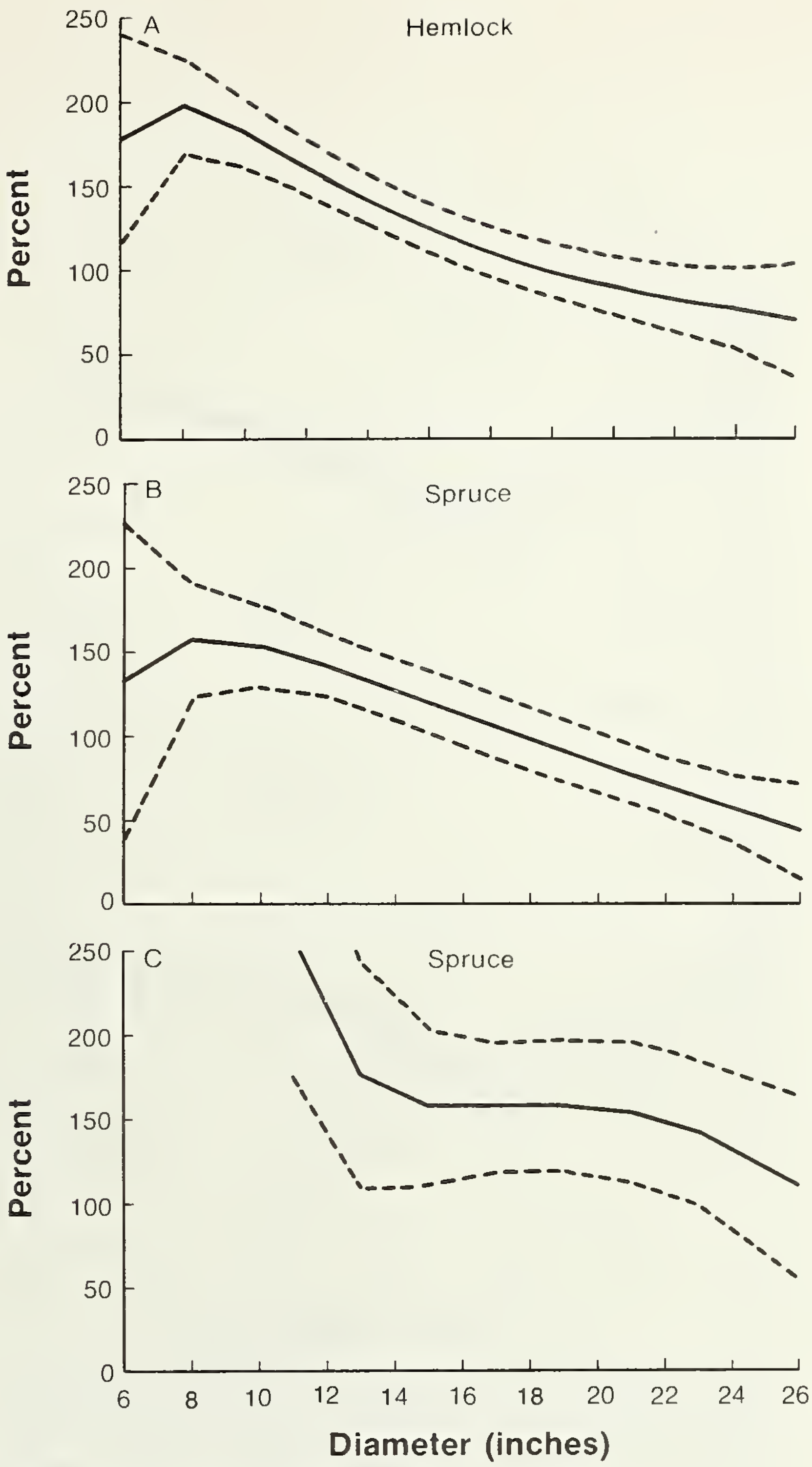

Figure 4.—Overrun curves (solid lines) and 95-percent confidence intervals (dashed lines) for hemlock and spruce logs processed at the dimension mill.
A. All the hemlock logs were combined to estimate this overrun curve. It has a fairly tight band of confidence except at the extreme ends of the data.
$OR = -134.1 + 2.2 (D) + 4638.1 (1/D) - 17094.6 (1/D^2)$;
$R^2 = 0.186$; $MSE = 76.9$.
B. The live and recent dead samples of spruce were combined for this curve. The band of confidence is similar to the one about the hemlock curve.
$OR = 118.5 - 4.9 (D) + 1701.1 (1/D) - 8617.8 (1/D^2)$;
$R^2 = 0.386$; $MSE = 49.0$.
C. This overrun curve is for the older dead sample of spruce. The band of confidence is much larger than those for the rest of the samples because of the small sample size and the great variation in defect.
$OR = 2992.1 - 54.5 (D) - 48933 (1/D) + 279989 (1/D^2)$;
$R^2 = 0.486$; $MSE = 81.1$.

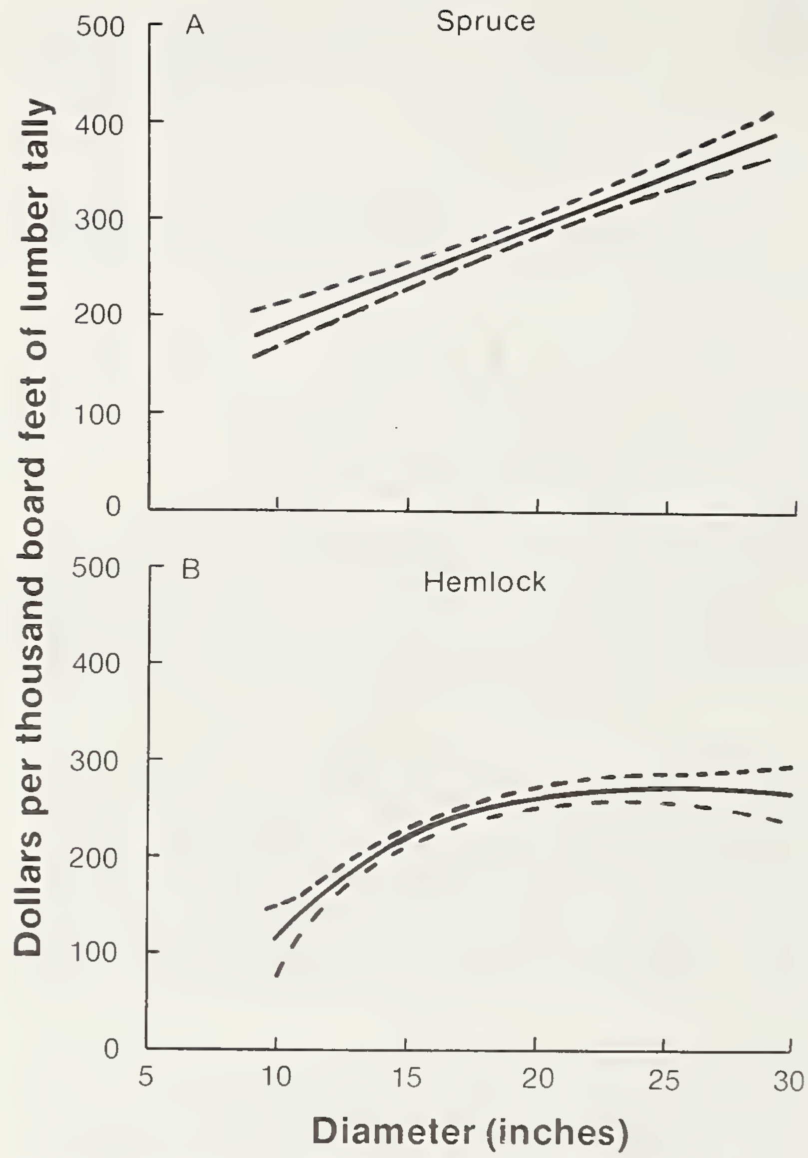

Figure 5.—Dollars per thousand board feet of lumber tally by diameter for spruce and hemlock logs at the cant mill.
A. The spruce logs were combined to estimate this curve, which is steeper for the spruce than the curve for the hemlock because of the pricing structure for the spruce.
$/MLT = 82.9 + 10.6 (D);
$r^2 = 0.56$; MSE = 54.8.
B. The hemlock logs were combined to estimate this curve.
$/MLT = 856.4 - 10.99 (D) - 8593.9 (1/D) + 22587.5 ($1/D^2$);
$R^2 = 0.42$; MSE = 42.3.

Only the spruce logs had a significant relationship between $/CCF and diameter (fig. 6). Covariance tests of the regression lines for the spruce logs and Tukey's tests of the averages for the hemlock logs both showed no significant difference between the live and recent dead samples, but there were significant differences when the live sample and the recent dead sample were combined and then compared with the older dead sample (table 4). These differences are a result of the interaction between the volume recovery and the value of the lumber. Even though the average value ($/MLT) was the same for all classes of logs, the volume recovered was less for the older dead logs; therefore, the net return ($/CCF) from the lumber is less.

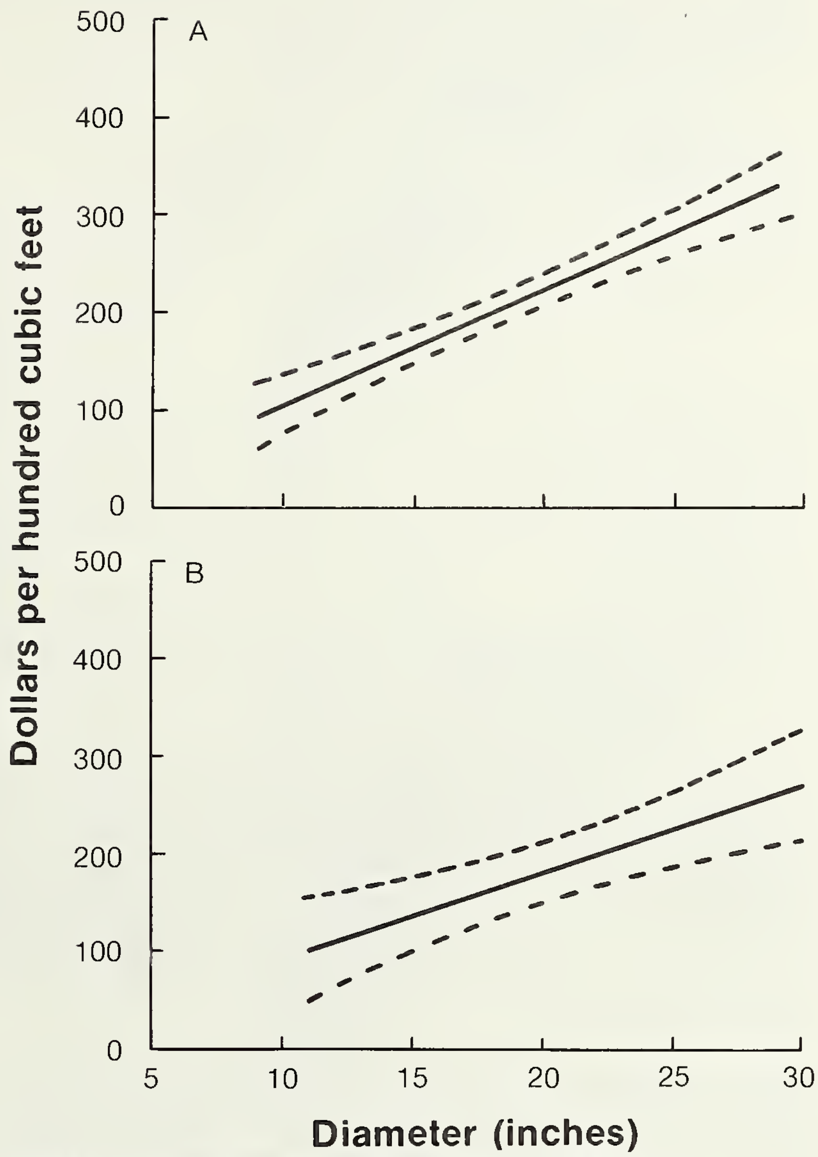

Figure 6.—Dollars per hundred cubic feet of log scale by diameter for samples of spruce processed at the cant mill.
A. The live and recent dead samples of spruce logs were combined to estimate this curve.
$/CCF = -14.7 + 11.9 (D);
r^2 = 0.49; MSE = 66.6.
B. The older dead sample of spruce was used to estimate this curve. The confidence intervals are much larger than those for the live and recent dead logs because of the greater percentage of defect.
$/CCF = 2.12 + 9.0 (D);
r^2 = 0.36; MSE = 71.8.

Table 4—Dollars per hundred cubic feet of log volume with 95-percent confidence interval for western hemlock beach logs sawn at the cant mill in southeast Alaska, by deterioration class for the beach logs

Deterioration class	Dollars per hundred cubic feet	95-percent confidence interval
Live and recent dead	151	18
Older dead	105	26

Table 5—Value of logs and lumber with 95-percent confidence intervals for the dimension mills by species and deterioration class for the beach logs from southeast Alaska

Species and deterioration class	Log value	95-percent confidence interval	Lumber value	95-percent confidence interval
	$/CCF		$/MLT	
Sitka spruce 1/	113	9	131	6
Western hemlock:				
Live and recent dead	122	7	143	6
Older dead	92	8	125	5

1/ All spruce logs are combined.

Neither $/MLT nor $/CCF had a significant relationship with diameter for the dimension mill. Analysis of variance and Tukey's test showed no difference for either dependent variable for the spruce samples (table 5). The live and recent dead samples of hemlock were not different, but they were different from the older dead sample. The lower value of the older dead hemlock logs appeared to be due to heart decay and checks. These defects reduce both the volume and value of the lumber recovered.

Volume by grade.—The percentage of volume by lumber grade varies by log diameter for the cant mill (fig. 7). For the hemlock logs, the percentage of volume graded No. 1 increased rapidly from 12 to 20 inches and remained relatively constant in the larger diameters. The percentage of volume graded No. 2 remained fairly constant over the entire range of diameters. Regular B was produced only from logs smaller than 20 inches, and this percentage rapidly decreased from 10 to 20 inches. The Light Framing was mainly a byproduct, averaging about 11 percent.

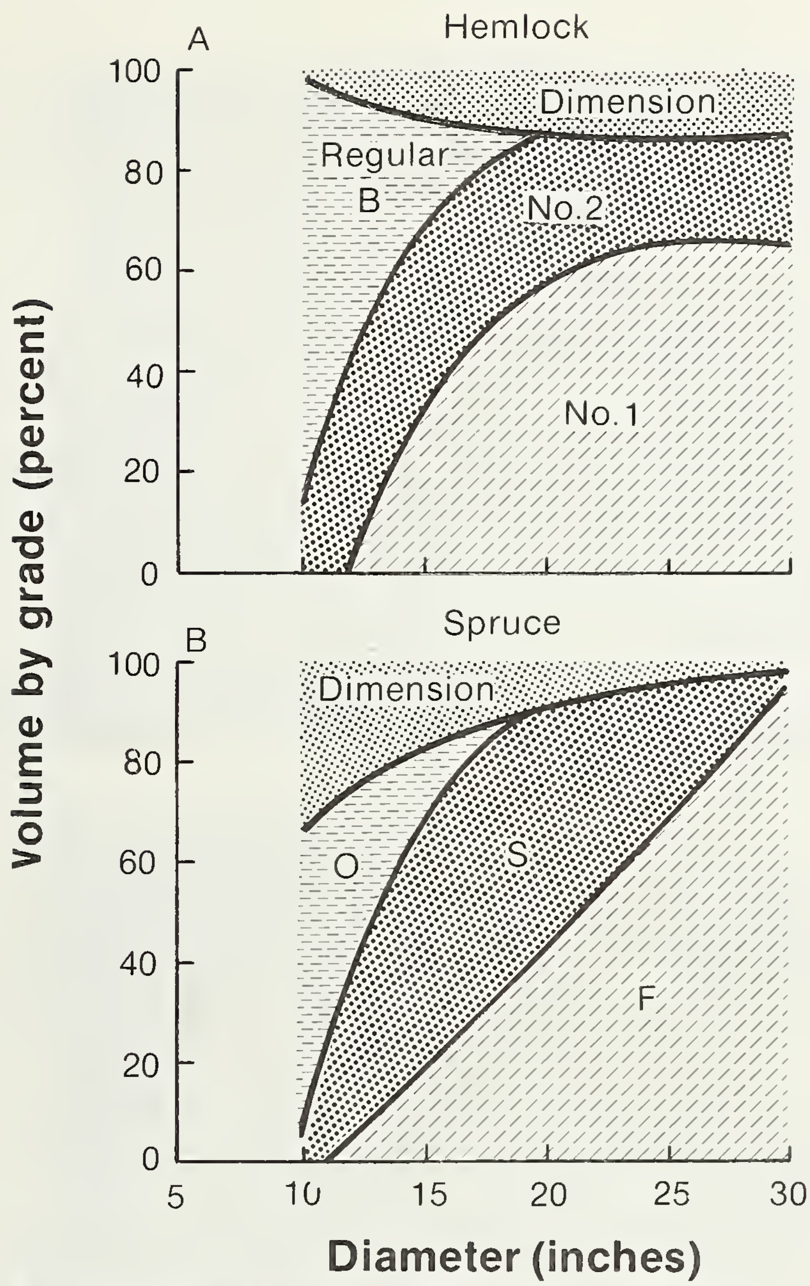

Figure 7.—Cumulative percentage of volume by lumber grade for western hemlock and Sitka spruce logs at the cant mill. The space between the curves represents the percentage of volume for individual lumber grades.

A. Equations for the cumulative percentages of volume by lumber grade of the hemlock logs are:

Percentage of No. 1 = 254.0 - 3.49 (D) - 2521.9 (1/D);
R^2 = 0.40; MSE = 28.9.

Percentage of No. 2 and No. 1 = 294.8 - 4.5 (D) - 2366.3 (1/D);
R^2 = 0.27; MSE = 28.0.

Percentage of Regular B, No. 2, and No. 1 = 55.9 + .658 (D) + 357.8 (1/D);
R^2 = 0.02; MSE = 20.2.

The percentage of Regular B, No. 2, and No. 1 is limited to logs from 10 to 19 inches in diameter.

B. Equations for the cumulative percentages of volume by lumber grade of the spruce logs are:

Percentage of F = -77.8 + 5.6 (D) + 191.9 (1/D);
R^2 = 0.55; MSE = 25.5.

Percentage of S and F = 296.3 - 4.0 (D) - 2517 (1/D);
R^2 = 0.54; MSE = 21.1.

Percentage of O, S, and F = 117.65 - .097 (D) - 507.6 (1/D);
R^2 = 0.11; MSE = 23.0.

The percentage of O, S, and F is limited to logs from 10 to 19 inches in diameter.

For the spruce logs, the percentage of volume graded F was nearly zero at 12 inches and increased to about 90 percent at 30 inches. The percentage of volume graded S remained constant until about 20 inches and then slowly decreased. All the volume graded O and most of the Light Framing came from logs smaller than 18 inches.

At the dimension mill no relationship was found between the percentage of volume by grade and diameter. The average percentage by lumber grade is given in table 6. Approximately 68 percent of the lumber volume from the spruce and combined live and recent dead hemlock samples was graded as Standard and Better plus Clear. Because the live and recent dead hemlock had twice as much Clear as the spruce had (fig. 8A), the average lumber value was higher. The percentage of low grade material (fig. 8B) for hemlock was higher for the older dead class than for the other classes and resulted in a lower average value for the older dead hemlock.

Table 6—Percent of volume in each lumber grade with 95-percent confidence intervals (CI) for the western hemlock and Sitka spruce beach logs sawn at the dimension mill

Species and deterioration class	Lumber grades							
	Clear	CI	Standard and Better	CI	Utility	CI	Economy	CI
	Percent							
Spruce	3.3	0.6	65.0	1.8	19.4	1.1	12.3	1.1
Hemlock:								
Live and recent dead	7.6	.8	60.5	1.6	20.9	1.1	11.0	.9
Older dead	3.8	.8	53.3	2.9	25.8	2.1	17.1	1.8

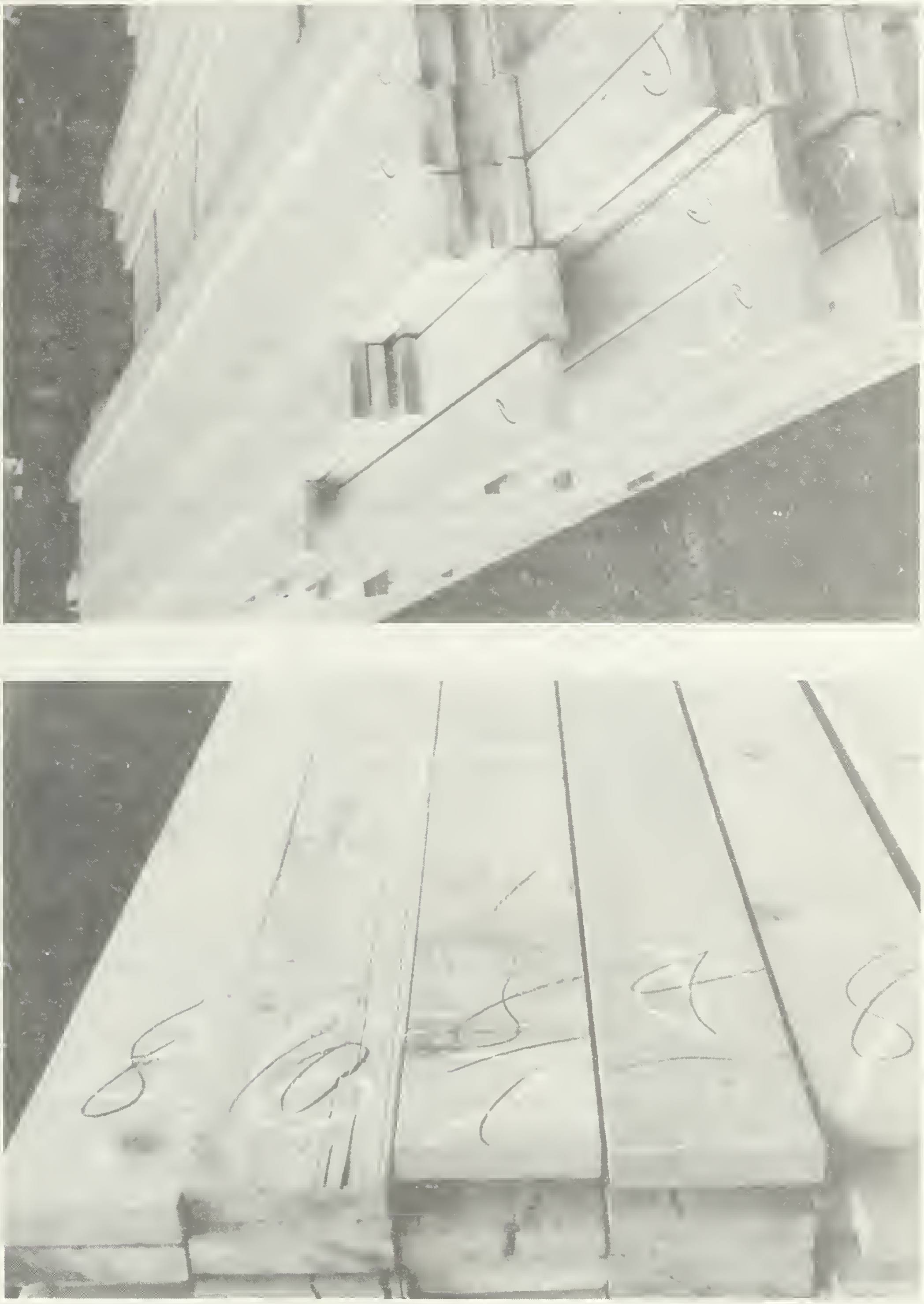

Figure 8.—Only 4 percent of the lumber produced from beach logs was Clear (A) and 15 percent was Economy lumber (B).

Summary and Conclusions

Cant mill.—Volume recovery expressed as either CR% or OR had no correlation with diameter. Average CR% and OR for each species and deterioration class are given in table 2. Average lumber value ($/MLT) did vary with diameter (fig. 5). Average log value ($/CCF) for spruce showed a relationship with diameter (fig. 6). Because there was no relationship with diameter for hemlock, average $/CCF are given in table 4. Values are higher for the spruce samples because of the different prices used for each species (appendix 2), not necessarily because of higher quality lumber.

Dimension mill.—Overrun had a relationship with diameter for both species (fig. 4). Average CR% for each species is given in table 3. Neither $/MLT nor $/CCF had a correlation with diameter; therefore, average values are given in table 5. In contrast to the cant mill, the prices used for the dimension mill were the same for both species.

In general, the recent dead and live samples for both species produced the same quality and volume of lumber at each mill. Less lumber was recovered from the older dead beach logs than for the recent dead and live logs. This loss may be due to the older dead logs being more defective or having a greater change in color. Especially in an export market, the tendency is to chip off-color material rather than to manufacture it into lumber or cants.

Although there may be problems with harvesting beach logs and with buyer acceptance, we found no adverse effects of sand and imbedded rocks. With some visual inspection boom nails can be avoided or eliminated. Other metal was no more prevalent than would be found in standing timber.

Pulp

Our objective for pulp was to compare a selected set of pulping characteristics of beach logs with freshly cut softwoods of the same species to determine whether beach logs were suitable for the manufacture of pulp.

Methods

Sample.—For the pulping analyses the sample was separated by species (hemlock and spruce) and origin (beach and live tree); no distinction was made between the deterioration classes of the beach logs. Throughout the 2 days of sawing, the sample was collected from the chips produced from slabs, edgings, and trim ends at the cant mill in Alaska. Approximately 60 pounds of chips from samples of live and beach logs for each species (240 pounds total) were sent to the Forest Products Laboratory in Madison, Wisconsin, to test their suitability for pulp.

Processing.—The samples were screened and only the chips between 1/4 and 3/4 inch were used for sulfite and kraft pulping experiments. The pulping experiments were conducted in a stationary stainless steel digester with a capacity of 0.8 cubic foot. Cooking liquor with an acid bisulfite magnesium base was used for the sulfite digestions. The conditions held constant included a liquor-to-wood ratio of 4 to 1, total sulfur dioxide of 8.4 percent, a digester pressurized with nitrogen gas to 80 lb/in^2, and a 3-1/4 hour rise to maximum temperature of 148 °C. For the two categories of spruce chips, the time at maximum temperature was 85 minutes. For the hemlock control sample the time was 55 minutes, and for the hemlock beach log sample the time was 75 minutes. It was necessary to vary the time at maximum temperature to yield screened pulps with a viscosity of 75 millipascal seconds.

Before they were bleached, the pulps were screened and cleaned in a centrifuge. Pulp yield was measured before and after screening. The yield and viscosity measurements are shown in table 7. Bleaching experiments were conducted with 0.25 lb cleaned samples of pulp by use of chlorination, extraction, two stages of hypochlorite, and one stage of sulfur dioxide (table 8). The bleached pulps were sampled for viscosity (table 8) and for chemical properties (table 9).

Table 7—Viscosity and yields from magnesium base bisulfite pulping of Sitka spruce and western hemlock beach logs from southeast Alaska

Species and origin	Time at 148 °C	Yield 1/		Viscosity
		Total	Screened	
	Minutes	- - Percent - - -		Millipascal seconds
Spruce:				
Control--				
Sample 1	85	46.1	41.3	76.0
Sample 2	85	46.8	42.5	76.5
Beach--				
Sample 1	85	46.5	43.3	74.0
Sample 2	85	46.9	43.8	82.2
Hemlock:				
Control--				
Sample 1	55	48.5	42.6	76.6
Sample 2	55	47.3	43.6	74.7
Beach--				
Sample 1	75	45.5	43.2	75.2
Sample 2	75	45.4	43.4	73.6

1/ Ovendry pulp to ovendry wood; screened through 0.010-inch flat screen.

Table 8—Bleaching conditions of sulfite pulp from Sitka spruce and western hemlock beach logs from southeast Alaska

Bleaching condition	Unit	Spruce		Hemlock	
		Control	Beach	Control	Beach
Yield (based on screened pulp)	percent	46.1	46.7	47.3	45.5
Viscosity 1/	mPa·s	76.0	74.0	74.7	75.2
Chlorination:					
Chlorine applied	percent	3.1	3.0	2.8	2.8
Chlorine residual	kg/metric ton	2.3	2.8	2.2	2.8
Yield	percent	45.1	44.8	46.5	44.0
Extraction yield	percent	43.1	42.8	43.0	40.5
First sodium hypochlorite:					
Applied	percent	.6	.6	.6	.6
Temperature	°C	42	44	44	44
Viscosity	mPa·s	31.5	29.5	31.5	30.5
Second sodium hypochlorite:					
Applied	percent	.4	.4	.4	.4
Temperature	°C	54	52	55	52
Viscosity	mPa·s	25.3	25.2	24.3	24.4
Total bleach consumption:					
Applied	percent	4.1	4.0	3.8	3.8
Consumed	percent	3.6	3.4	3.4	3.2
Yield	percent	41.4	42.3	41.8	39.8

1/ Pulp run at 0.5 percent concentration in Cupriethylenediamine, according to TAPPI T-230.

Table 9—Properties of the bleached sulfite pulps from Sitka spruce and western hemlock beach logs from southeast Alaska

		Sitka spruce		Hemlock	
Property	Unit	Control	Beach	Control	Beach
Yield (based on wood)	percent	41.4	42.3	41.8	39.8
Brightness (Elrepho)	percent	92.3	91.7	92.4	92.8
Drainage time (British)	seconds	3.9	3.8	4.0	4.0
Ash	percent	.3	.3	.3	.3
Viscosity 1/	mPa·s	25.3	25.2	24.3	24.4
Solubilities:					
18 percent cold caustic 2/--					
Stage 2, alpha	percent	91.3	90.6	92.0	91.5
Stage 2, beta + gamma	percent	8.7	9.4	8.0	8.5
Stage 4, alpha	percent	90.3	89.8	91.3	90.4
10 percent cold caustic 2/--					
Stage 4, beta	percent	2.34	3.09	2.05	2.50
Stage 4, gamma	percent	7.32	7.10	6.67	7.06
Alcohol benzene	percent	.37	.35	.38	.26
Hot potassium hydroxide 3/	percent	11.14	10.50	11.65	11.30

1/ Pulp run at 0.5 percent concentration in Cupriethylenediamine, according to TAPPI T-230.

2/ According to TAPPI T-203.

3/ According to TAPPI T-212.

Table 10—Yields and kappa number from kraft pulping of Sitka spruce and western hemlock beach logs from southeast Alaska

Species and origin	Active alkali	Time at 170 °C	Yield 1/ Total	Screened	Kappa number 2/
	Percent	Minutes	- - Percent - -		
Spruce:					
Control	21.5	105	44.5	42.5	24
Beach	21.5	105	43.2	41.6	24
Hemlock:					
Control	21.5	105	44.1	43.3	25
Beach	21.5	105	44.4	43.1	25

1/ Ovendry pulp to ovendry wood; screened through 0.010-incn flat screen.

2/ According to TAPPI T-236.

The conditions for the kraft digestions were: liquor-to-wood ratio 4 to 1; 25 percent sulfidity; 21.5 percent active alkali; temperature rise of 90 minutes to 170 °C and 105 minutes at this temperature. At the end of each digestion, the liquor was blown from the digester, and the chips were immediately washed with 90 °C water and disintegrated to pulp. The resulting pulps were then screened through a flat screen (0.010-inch slots) and sampled to determine yield, kappa number, and strength development according to TAPPI standard methods (table 10). No statistical analyses were done on the observed responses.

Results and Discussion

The results show that the beach logs can be used for producing both sulfite and kraft pulps. The chips from the spruce logs recovered from the beach had pulping characteristics similar to the control material. The cooking conditions did not have to be altered to produce a pulp with given yield. This was likewise true in kraft pulping of the hemlock. The sulfite pulping experiments with the hemlock required a longer cooking schedule when chips from the beach logs were used rather than chips from the control logs.

No significant problems arose in the bleaching of the sulfite pulps. The total bleach chemical requirement was nearly the same for the pulps produced from the beach logs as for those from the respective control logs (table 8). The viscosities, solubilities, and ash contents were also similar (tables 8 and 9). These similarities indicate that the beach logs should have potential for production of viscose pulps.

Table 11—Properties of beaten kraft pulps from Sitka spruce and western hemlock beach logs from southeast Alaska[1/]

Species and origin	Canadian standard freeness	Beating time	Burst index	Tear index	Tensile index	Thickness	Density	Brightness 2/ (Elrepho)
	ml	minutes	$kPa \cdot m^2/g$	$mN \cdot m^2/g$	$N \cdot m/g$	mm	kg/m^3	percent
Sitka spruce:								
Control--								
Sample 1	550	30	7.0	12.1	118	0.084	700	25.8
Sample 2	450	42	9.2	11.1	125	.077	730	
Beach--								
Sample 1	550	24	8.8	11.4	104	.084	710	25.7
Sample 2	450	35	9.1	10.7	114	.081	730	
Hemlock:								
Control--								
Sample 1	550	28	7.0	10.3	114	.084	700	22.8
Sample 2	450	38	7.4	9.5	118	.081	735	
Beach--								
Sample 1	550	25	6.8	12.4	110	.088	680	25.6
Sample 2	450	35	8.9	11.2	116	.083	715	

1/ According to TAPPI standards.

2/ Average for sample 1 and sample 2.

Bleaching experiments were not done on the kraft pulps, but the unbleached pulps were beaten and evaluated. Results shown in table 11 indicate no difficulty in developing strength in sheets produced from the pulps made from beach log chips. These sheets had burst strengths higher than sheets made from pulps produced from the control logs. The tear strengths were lower for the spruce and higher for the hemlock.

Energy

Two major problems addressed were the general lack of information about the energy potential and the effects of salt and other contaminants in the wood on boilers, chimneys, and stacks.

Smith and Woodfin (1984) determined the sodium and other inorganic contents and the basic fuel characteristics of Sitka spruce and western hemlock beach logs. They found the sodium content was 16 to 23 times greater in western hemlock and 14 to 22 times greater in Sitka spruce than the values found in the literature for logs not subjected to salt contamination. No significant differences in sodium content were found about radial position.

Smith and Woodfin (1984) found that the higher heating values for Sitka spruce were significantly greater than those found in the literature, and those for western hemlock were about the same. They offered no explanation for this.

Detrimental effects can occur when beach logs are burned because the logs contain high levels of sodium. Sodium chloride particles contained in the fly ash are submicron in size and are very difficult to capture in collectors. This can result in an increase in stack emission and stack opacity.

Lamorey and Goss (1983) determined gasification characteristics of the beach log material. Gasification is the conversion of solid carbonaceous fuel such as coal or biomass to a combustible gas by partial oxidation. The combustible gas can then be used to fire a burner or to run an internal combustion engine.

Tests of the wood chips before gasification showed that the beach log material had lower original moisture content. The lower moisture content is advantageous because wood with a moisture content of less than 18 percent is needed for the best performance in a gasifier; therefore, the beach log material would require less drying. Gasification of each of the samples produced the same amount of char and fly ash.

Lamorey and Goss (1983) concluded that neither the beach log material nor the control sample caused any operational problems during gasification. No differences were found in any of the gasification characteristics among any of the samples. They did recommend further testing of the effects of gasifying a salty fuel before gasifying beach wood residues on a large scale.

Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 0.3048 meter
1 square foot = 0.0929 square meter
1 cubic foot = 0.02832 cubic meter
1 pound = 453.6 grams
1 quart = 0.947 liter
1 ton = 0.907 metric ton
1 pound per square inch = 6.894 kilopascals
1 pound per square inch square foot per pound = 0.001412 kilopascal square meter per gram
1 pound-force square foot per pound = 0.000911 millinewton square meter per gram
1 pound-force foot per pound = 0.00299 newton meter per gram
1 pound-force second per square foot = 0.04788 millipascal second

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Appendix 1

A brief summary of the contractual export grades between the Alaska cant mill owners and the buyers from Japan.

Hemlock

No. 1:

For 8-inch cants—

Must be free of heart center, maximum volume deduction of 25 percent, and maximum width of 24 inches.

For 4-inch cants—

Must be shop grade and better, one square edge, maximum volume deduction of 25 percent, minimum 4-inch full face, minimum of 50 percent door cuttings, no heart centers, and no teredo holes.

No. 2:

For 8-inch cants—

Heart center allowed in cants larger than 11 inches, no more than 33 percent in deductions.

For 4-inch cants—

Standard or common grade cants, heart centers allowed, must have one square edge, and deductions of no more than 33 percent

Regular B:

Heart centers allowed, must have two slabbed sides, and deductions of no more than 33 percent. Generally 10 to 15 inches wide and used to resaw for construction lumber.

Spruce

F:

Must meet factory and shop grades, must be free of heart center on both ends, and must be cut from logs 24 inches or more.

S:

Must meet factory and shop grades, heart center is allowed, and must be cut from 16- to 23-inch logs.

O:

Heart centers allowed, must have two slabbed sides, and deductions of no more than 33 percent. Generally 10 to 15 inches wide and used to resaw for construction lumber.

Appendix 2

Prices by lumber grade used in this report are based on 1982 prices quoted by the mills at the time of processing:

Mill, species, and lumber grade	Price
Cant mill:	($/MBF)
Hemlock—	
No. 1	300
No. 2	225
Regular B	150
Spruce—	
F	400
S	225
O	150
Dimension mill:	
Hemlock and spruce—	
Clears	325
Standard and Better	150
Utility	110
Economy	65

*GPO 692-665 1986

Ernst, Susan; Plank, Marlin E.; Fahey, Donald J. Sitka spruce and western hemlock beach logs in southeast Alaska: suitability for lumber, pulp, and energy. Res. Pap. PNW-352. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; 1986. 25 p.

The suitability of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) beach logs in southeast Alaska for lumber, pulp, and energy was determined. Logs were sawn at a cant mill in southeast Alaska and at a dimension mill in northern Washington. Volume and value recovery was compared among samples of live, recent dead, and older dead classes of logs. The live and recent dead samples produced about the same quantity and quality of lumber. The older dead sample produced less volume and lower quality lumber. There were no difficulties in pulping or gasification of the beach logs, but a higher salt content may cause problems with boiler corrosion and stack emissions.

Keywords: Wood utilization, beach logs, western hemlock, Sitka spruce, southeast Alaska.

Pacific Northwest Research Station
319 S.W. Pine St.
P.O. Box 3890
Portland, Oregon 97208

S. Department of Agriculture
ıcific Northwest Research Station
9 S.W. Pine Street
D. Box 3890
ırtland, Oregon 97208